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MATURITY TESTS FOR TABLE GRAPES

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MATURITY TESTS FOR TABLE GRAPES[1]

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The numerous tests and examination of table grapes made in efforts to ascertain the proper stage of maturity at which they should be picked have dealt primarily with the chemical composition of the fruit. Except for the work of Bioletti and Zion, as reported by Bioletti,[3] little or no attempt has been made to determine directly the correlation between the palatability—eating quality—of the analyzed fruit and its chemical components such as sugars or acids. Bioletti and Zion attempted to discover how far the sugar content as measured by a hydrometer and expressed as degrees Balling of the expressed juice, could be relied upon to indicate the eating quality of the grapes and what advantage there would be in the substitution or addition of the acid test or of the sugar: acid ratio. Their conclusion was that the Balling hydrometer test is the simplest and most reliable that can be used practically in determining the degree of ripeness of grapes for the purpose of standardization. According to their data the Emperor was good when it reached 19° Balling, the Malaga and Tokay when they reached 21° Balling, and the Thompson Seedless (Sultanina) when it reached 18° Balling.

The degrees Balling indicated by Bioletti and Zion for the varieties included in their work, however, have not been accepted by the growers, presumably because they have been considered to be too high. This difference of opinion together with the lack of information which has confronted the grape growers each time the Standardization law of 1915 has been amended, expanded, or contracted, shows the need of a better method of determining the minimum stage of maturity at which table grapes should be harvested. This need of a better method of determining maturity has been increased on the one hand by a desire on the part of many growers to improve quality and on the other hand by a continued insistence on the part of a few growers to move their fruit as early as possible, regardless of whether or not it has reached a stage of maturity which is satisfactory to the consumers.

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[3] Bioletti, F. T. The basis of grape standardization. California Agr. Exp. Sta. Cir. 293:1–16. 1925.

In an attempt to discover evidence which might help to overcome some of the difficulties of determining the stage of ripeness at which grapes should be harvested, the Division of Viticulture began a general investigation of the maturity of table grapes in 1927. It was our purpose to determine (1) the factors of composition of the grape which exert the greatest influence on palatability, (2) the influence of variety upon the relation of composition to palatability, (3) the influence of regional and seasonal conditions upon composition and palatability, and finally, (4) the possibility of establishing a more satisfactory means of determining maturity in relation to palatability than the present one of measuring only the degree Balling of the expressed juice.

METHOD OF PROCEDURE

The method of procedure was similar to that employed by Bioletti and Zion, the principal differences being that all samples were scored for eating quality by six or more individuals instead of only three or more and that all samples were scored by a group of individuals residing in Davis. The larger number of scorers represented better the taste of the average consumer and being unconnected with the locality where the grapes were grown were free from any unconscious bias in favor of a product of their own locality.

Collection of Samples.—During 1927 and 1928, while the methods of scoring and analysis were being tested, the collection of samples was confined to the table grape varieties in the University Farm vineyards at Davis. Each day during the harvesting season one lot of twelve samples was collected so as to represent a range of ripeness from well below what would be considered fair in eating quality to what would be considered good to excellent. Each lot was composed of a single variety. The individual samples of a lot represented approximately five pounds of grapes of as nearly the same degree of ripeness as it was possible to obtain by tasting each cluster before it was removed from the vine. In the seasons of 1929, 1930, and 1931 samples of the leading table grape varieties in the ripening range, i.e. from poor to good in eating quality, were also collected from all of the principal districts of the state in which they are grown. In these collections usually only one lot, and at most two lots, of twelve samples of one variety were obtained from one grower. Six or more lots of each variety were obtained in each of the principal districts. By collecting only one lot of a variety from a ranch and obtaining fruit from as many locations in a district as possible, fruit which was fairly representative of the district was obtained.

After collection, the samples were immediately shipped to Davis by express and stored at 30° F until the day before they could be scored and analyzed. The fruit was always brought to room temperature for the scoring. In no case was the storage period sufficiently long to result in any appreciable changes in the quality of the fruit. The samples from the University Farm vineyards were scored and analyzed on the day they were collected.

Scoring the Samples.—The samples of one lot of fruit were placed at random on a table and numbered from one to twelve. The individual scorers then tasted a sufficient number of the berries from various parts of the clusters of each sample to enable them to designate its eating quality as poor, fair, good, very good, or excellent. Of the total group of 43 individuals that cooperated in the scoring at least 6 and usually not more than 8 tasted each sample of a lot of fruit. Each of the individuals scored the samples of fruit independently. This method of scoring along with the fact that only one lot of fruit was scored on one day which was not enough to deaden the power of discrimination of the tasters, resulted in a fairly accurate evaluation of the relative eating quality of the samples. That this was true is indicated by the precision with which the poor samples are separated from the good in the tables presented in connection with the discussion of the Balling-acid ratio as a means of measuring palatability.

To make it possible to average scores, the terms used to designate eating quality were given a numerical value. The scoring for one lot of fruit and the average numerical scores for each sample are shown in table 1.

Analysis of the Samples.—After scoring, the samples collected in 1927 and 1928 were pressed and the juice analyzed to determine its sugar content, pH, and acidity. The sugar content was determined by chemical means, with a refractometer, and by the Balling[4] hydrometer. Each of the samples was passed through a motor-driven continuous press to express the juice. While this method of pressing did not remove all of the juice it resulted in a uniform extraction so that the expressed juice was representative of the sample of fruit used. After pressing, the juice was placed in tall beakers and left standing for a time to allow any suspended solid material to settle. When the settling out was very slow, this material was removed by straining through several layers of cheesecloth or by centrifuging.

[4] The Balling hydrometer scale is for all practical purposes the same as the Brix scale.

For the chemical analysis the juice was clarified with neutral lead acetate and the excess lead removed with potassium oxalate; the sugar reductions were carried out according to the Schaffer-Hartman[5] method. The refractometer determination of the sugar was made with a laboratory type Abbe refractometer. For the determination of degrees Balling see the next section.

The two methods of determining the sugar in addition to the Balling degree reading were used in order to determine the relative accuracy with which the sugar content in the juice is measured by the three methods. Since Balling degree is a measure of the specific

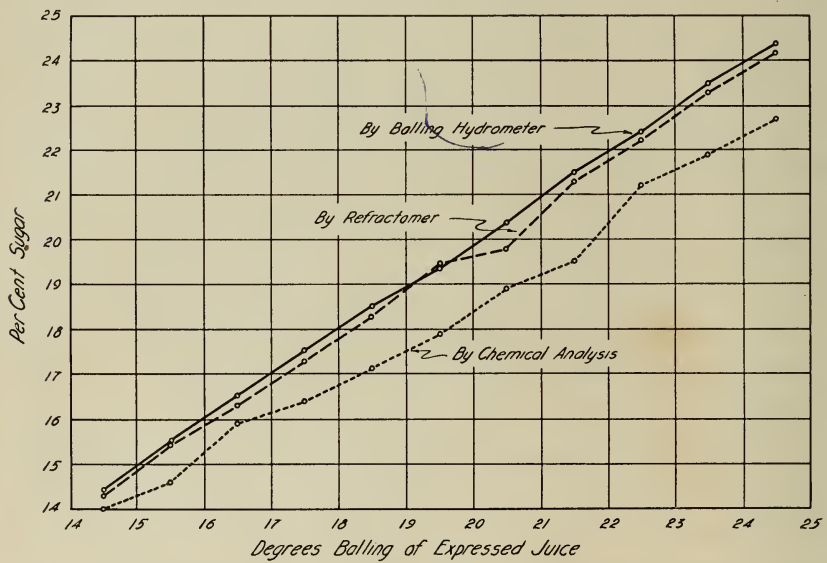

Fig. 1.—A comparison of the results obtained on expressed grape juice by means of the Balling hydrometer, the refractometer, and chemical analysis.

gravity which is influenced by all of the soluble solids, the question has arisen in the minds of many growers as to whether or not it is a reliable measure of eating quality, which is probably influenced more by the sugar content of the grapes than by any one of the other constituents. Figure 1 shows the results obtained with the three methods, using 378 samples which were regularly distributed among eight varieties and over the range of 14.5° to 24.5° Balling.

The graphs showing the results obtained by the three methods are fairly concordant and indicate that each might be used as a guide

[5] Shaffer, P. A., and A. F. Hartman. The iodometric determination and its use in sugar analysis. Jour. Bio. Chem. 45:349–390. 1920.

for standardization. The hydrometer and refractometer readings are very close together; the greater difference of the chemical analysis is due to the fact that it measures only the sugar, while the others are affected by nonsugar solids as well. The apparent irregularity of the graph of chemical analysis is due to the fact that the Balling readings have been used as the standard by which the division of grape samples into groups was made, and the Balling line is thus straight by construction. The irregularities in the other lines indicate simply deviations between the three methods, and do not necessarily indicate that any has an advantage over the others.

The results presented in figure 1 are confirmed by those of other workers.[6] This is true both for the relatively small error of the Balling readings and for the greater irregularity in the results of an analysis for sugar by chemical means.

In the case of mature, and approximately mature, vinifera table grapes it would seem, therefore, that degree Balling gives a very accurate relative measure of the sugar content of the expressed juice. It may without question be accepted as the most practicable means of determining the sugar content of grape juice under field conditions. It is to be recommended over the refractometer because the latter requires very small quantities of juice. Only one or two drops can be used for a determination. Working with such small amounts of juice, which may be obtained from a single berry, the error of sampling may be very large.

In view of the above results on the determination of the sugar content of the expressed juice and to facilitate the work, Balling degree readings alone were taken after the 1928 season.

Balling Degree.—The cleared juice as obtained by settling or straining was poured into a tall glass cylinder, the cylinder being always filled to overflowing so that the foam, which formed when the juice was poured in, ran off. A Balling or Brix hydrometer was then carefully placed in the filled cylinder. When the instrument came to rest, the reading on the spindle at the surface of the liquid was recorded and also the temperature of the juice.

Hydrometers, calibrated to 0.1 per cent of sugar at 63.5° and 82.5° F were used. A correction was made for any variation from the calibration temperature. This temperature variation[7] is about 0.1°

[6] Bioletti, F. T., W. V. Cruess, and H. Davi. Changes in the chemical composition of grapes during ripening. California Pub. Agr. Sci. 3:103–130. 1918.

[7] Official and tentative methods of analysis of the Association of Official Agricultural Chemists. Published by the Association of Official Agricultural Chemists, Washington, D. C. 2nd Ed. p. 428. 1925.

Balling for every 3° F above or below the calibration temperature of the instrument used.

Acidity.—In determining the acidity 10 cc of the clear juice was pipetted into a 300 cc Erlenmeyer flask and made up to approximately 100 cc with distilled water. After adding 3 drops of phenolphthalein indicator, the titration was made with sodium hydroxide which had been standardized so that 1 cc was equivalent to 0.01 gram tartaric acid. Care was exercised to stop the titration at the first definite color change. While it is realized that the titration of grape juice against phenolphthalein gives results which are high, no other indicator which could be used in the field gave more accurate results.

It is essential that only clear juice, i.e., juice free from fiber and other solid parts of the berry which come through in pressing be used in the acidity determinations. Failure to use clear juice gave results which were 10 to 100 per cent too high. This was owing probably to the tannin content of the fibrous material which reacts with the sodium hydroxide.

Determinations for pH were made on the clear juice in 1927. The change in the pH of the expressed juice of grapes as they developed from the stage of being almost mature to full maturity (say 16° to 22° Balling) was small. There was no clear-cut relation between pH and eating quality.

Scope and Nature of the Data.—During the seasons of 1927 to 1931, inclusive, data similar to those shown for the twelve samples of table 1 were collected for 3,680 samples. This number of samples was distributed among the varieties used as follows: Thompson Seedless (Sultanina), 875; Malaga, 760; Tokay, 492; Emperor, 460; Ribier, 325; Molinera (Red Malaga), 260; Muscat, 200; Ohanez (Almeria), 120; Cornichon, 72; Rish Baba, 68; and Olivette Blanche, 48. The large numbers of samples of Thompson Seedless and Malaga as compared with the other varieties were used because of the wide distribution of these two varieties. They are grown under more varied climatic conditions than all of the other varieties combined.

After the preliminary tests which showed that it would be injudicious to continue with certain of the determinations, the data collected for each sample consisted of the score for eating quality, the degree Balling, and the per cent acidity of the expressed juice. The Balling-acid ratio was calculated from the degree Balling and the per cent acidity. A complete record for a single lot of fruit is shown in table 1.

The scores shown in table 1 indicate the nature of the scoring. Even in this very limited number of samples, the individuality of the tasters is reflected. Scorer *1,* for instance, marked all of the samples with one exception, as low or lower than anyone else, while scorer *4* marked each of the samples as high or higher than anyone else. The opinions of scorers *3, 5,* and *6* were in close agreement and scorer *2* marked the samples only a bit more severely. Such differences as these are to be expected since no two individuals have identical tastes. The relative placing of the samples also varied from day to day, apparently being influenced by the health and disposition of the scorer at the time the scoring was done.

TABLE 1

The Scoring, the Numerical Score, and the Analytical Data for One Lot of Thompson Seedless (Sultanina)

Sample No.	Scorers with their scores						Average numerical score*	Degree Balling	Per cent acid, as tartaric	Balling—acid ratio
	1	*2*	*3*	*4*	*5*	*6*				
1	Fair −	Poor	Fair	Fair	Fair −	Fair	18.1	15.6	0.93	17
2	Poor	Poor +	Good −	Fair +	Poor +	Poor +	16.5	15.4	0.91	17
3	Good −	Good	Good	Good +	Good	Good −	48.7	20.4	0.74	28
4	Fair	Fair	Good −	Good	Good −	Good −	38.2	18.8	0.72	26
5	Fair +	Fair +	Good	Good	Fair +	Good	41.5	20.2	0.73	28
6	Good −	Good	Good	Good	Good	Good	48.7	20.9	0.67	31
7	Poor	Poor	Fair	Fair	Poor	Fair −	11.2	14.2	0.95	15
8	Fair	Good −	Fair	Good −	Fair −	Fair	29.4	16.4	0.87	19
9	Fair −	Fair −	Fair −	Fair	Fair −	Fair −	18.3	14.1	0.90	16
10	Good	Very good	Good +	Very good	Good	Good +	61.0	21.0	0.67	31
11	Fair	Fair	Fair	Good +	Fair	Fair	30.5	17.0	0.85	20
12	Good −	Good +	Good	Good	Good −	Good	48.7	19.3	0.70	28

* Numerical values of the scores: Poor=0; fair=25; good=50; very good=75; and excellent=100. A plus (+) or minus (−) =8.

Some of the differences in the scoring were also due to the difference in the maturity of the individual berries on the clusters. Although great care was exercised in selecting the fruit for each sample, yet it was obviously impossible to have all of the clusters and berries of one sample of identically the same stage of maturity. It was obviously impractical to have the different scorers taste parts of the same berries, hence no two scorers were tasting identical berries. Such variances from the other scores as that given by scorer *4* on sample 11 were, no doubt, owing to the fact that this scorer tasted berries which were far above the average in quality for the sample.

Despite these influences the accuracy of the scores may be considered sufficient for the purpose of classifying the samples. There is all reason to believe that they are equal if not superior to any which could be obtained by other means. Where a sufficient number of samples were scored by the same group of individuals to permit of statistical treatment the greatest difference between scorers for the same samples was only about 5 per cent.

THE INFLUENCE OF REGIONAL CONDITIONS ON THE DEGREE BALLING, PER CENT ACIDITY, AND PALATABILITY OF GRAPES

The influence of regional conditions upon the eating quality of grapes has been recognized in a general way for many years. In fact, it was incorporated in the California Standardization law until 1931. Sufficient figures to prove the definite relation with palatability, however, have been lacking.

The Influence of Regional Conditions on Composition.—In comparing the influence of regional conditions on the composition of the fruit, samples were obtained from the following regions: (1) Coachella and Imperial valleys, (2) Kern County, and (3) the region from Fresno to Davis. The first of these regions is typical of the hot arid desert. The region Fresno-to-Davis is considerably cooler than the first named in that it is subject to the influence of the ocean breezes that come in from the San Francisco Bay region. Kern County is intermediate.

The process of ripening in the grapes is a continuous one. This being the case, there is no maximum in the sugar content nor minimum in the acid content at which a grape can be said to be ripe. The relative rates in the change of these substances also influences the time at which the fruit becomes palatable. A rapid decline in acidity may result in the fruit becoming palatable at a relatively low sugar content. On the contrary, a rapid accumulation of sugar with a slow decline in acidity may result in the development of fruit which is palatable at a very high acid content because its sugar content also is high. Palatability is influenced not only by the quantity of each of these substances in the fruit but also by their relation to one another.

For the purpose of comparing fruit of one region with that of another it is necessary to employ some definitely measurable factor as a basis. For this purpose both the degree Balling and the per cent acidity have been employed. The regional influence on the degree

Balling of grapes of the same per cent acidity is shown in table 2. This same influence on the per cent acidity and the relation of the sugar to the acid content of the fruit of the same degree Balling is shown in table 3.

TABLE 2

The Influence of Regional Conditions on the Degree Balling of Grapes of the Same Acid Content

Variety	Region	Per cent acid						
		0.55 to 0.60	0.60 to 0.65	0.65 to 0.70	0.70 to 0.75	0.75 to 0.80	0.80 to 0.85	0.85 to 0.90
		Degree Balling						
Thompson Seedless	Coachella and Imperial valleys	18.4	18.6	18.0	18.5	18.0	.....	.....
	Kern County	.....	19.4	19.8	19.3	19.0	18.9	.....
	Fresno-to-Davis	.....	.....	21.8	21.5	21.9	21.5	21.9
Malaga	Coachella and Imperial valleys	18.5	18.1	18.5	18.3	18.5	.....	.....
	Kern County	.....	19.3	19.4	19.6	19.8	18.7	.....
	Fresno-to-Davis	.....	.....	21.6	21.3	21.4	20.7	20.4

The figures of table 2 show the influence of the conditions of the three regions on palatability rather than the relation which existed between degree Balling and acidity during normal ripening in these regions. Usually grapes of high acidity would be relatively low in sugar and those of low acidity would have a relatively high sugar content. Since the samples were collected by taste so that they would fall within a relatively narrow range of palatability from just below what would be considered fair in eating quality to what would be considered good this normal relation of degree Balling to acidity was almost completely upset. The relation of acidity to eating quality was not disturbed by this method of sampling. Of the fruit collected in the Coachella and Imperial valleys 100 per cent of the samples of 0.55 to 0.60 per cent acidity were scored fair or better by the tasters, while only 33 per cent of the samples of 0.75 to 0.80 per cent acidity were scored fair or better. A similar relative influence of acidity on eating quality was shown by the sample of fruit from the other regions.

Samples collected in this way, however, clearly show the influence of regional conditions on eating quality. In the Thompson Seedless the Balling reading of the fruit of the Fresno-to-Davis region was

2.4° higher than that of Kern County and 3.3° higher than that of the Coachella and Imperial valleys region. The fruit of Kern County was 0.9° Balling higher than that of Coachella and Imperial valleys. For the Malaga the samples of the Fresno-to-Davis region were 2.7° Balling higher than those of Coachella and Imperial valleys and 1.7° Balling higher than those of Kern County. In this variety the samples from Kern County were 1.0° Balling higher than those from the Coachella and Imperial valleys. In other words, for the fruit of the three regions to be of the same eating quality that of Kern County must contain sufficiently more sugar to increase its Balling reading about 1°, and that of the Fresno-to-Davis region enough more to increase its Balling reading about 2.5° above that of the fruit of the Coachella and Imperial valleys.

TABLE 3

THE INFLUENCE OF REGIONAL OR CLIMATIC CONDITIONS ON PER CENT ACID AND THE BALLING-ACID RATIO OF GRAPES OF THE SAME DEGREE BALLING

Variety	Degree Balling of the expressed juice	Coachella and Imperial valleys	Kern County	Fresno-to-Davis
		Per cent acid		
Thompson Seedless	17.0 to 17.9	0.73	0.80	0.85
	18.0 to 18.9	0.70	0.78	0.82
	19.0 to 19.9	0.69	0.71	0.74
Malaga	17.0 to 17.9	0.69	0.80	0.81
	18.0 to 18.9	0.64	0.73	0.77
	19.0 to 19.9	0.59	0.69	0.71
		Balling-acid ratio		
Thompson Seedless	17.0 to 17.9	24:1	22:1	22:1
	18.0 to 18 9	26:1	24:1	23:1
	19.0 to 19.9	28:1	27:1	26:1
Malaga	17.0 to 17.9	25:1	22:1	22:1
	18.0 to 18.9	29:1	25:1	24:1
	19.0 to 19.9	33:1	28:1	27:1

These differences in the degree Balling at the same per cent acidity may be the result of several conditions. The most generally accepted theory is that the acidity of the fruit is reduced more rapidly in the hotter regions. This belief is supported by the figures on acidity in table 3. The difference may also result from a retarded accumulation of sugar and a rapid reduction of the acidity in the hotter

regions. This idea is supported by the fact that the sugar content of the fruit in hot seasons in the hot regions never gets very high. A third possible cause for this difference might be a greater accumulation of sugar and a smaller reduction in acidity in the cooler regions. It is a recognized fact that the largest accumulation of sugar takes place in such regions as that of Fresno-to-Davis—the coolest region considered in these comparisons.

The figures of table 3 show a decided increase in the acid content of the grapes of the Kern County and the Fresno-to-Davis regions over that of the Coachella and Imperial valleys region. In the Thompson Seedless this increase was 16.5 per cent at 17° Balling, 17.1 per cent at 18° Balling, and 7.2 per cent at 19° Balling, for the Fresno-to-Davis region.

In the Malaga the differences in the per cent acid for the Kern County and Fresno-to-Davis regions over that of the Coachella and Imperial valleys region were still greater. The increase in favor of Kern County was 16.0 per cent at 17° Balling, 14.1 per cent at 18° Balling, and 17.0 per cent at 19° Balling. In the Fresno-to-Davis region the increase over that of the Coachella and Imperial valleys region was 18.4 per cent at 17° Balling, 20.3 per cent at 18° Balling, and 20.4 per cent at 19° Balling.

The above figures definitely show the influence of regional conditions on the acidity of grapes. The differences are all clearly significant when the comparisons are made between the Coachella and Imperial valleys region and the other two regions. The same is true of the differences for the Thompson Seedless between the Kern County and the Fresno-to-Davis region. In the Malaga the difference in per cent acid in the Kern County and the Fresno-to-Davis regions was relatively small. This was possibly owing to the relatively later harvesting of this variety in the latter region. This longer exposure of the grapes to the conditions prevailing in late summer in this region would tend to reduce the acid content.

The Balling-acid ratio shown in table 3 is simply a function of degree Balling and the per cent acid. It shows the influence of regional conditions on both the sugar and the acid content of the grapes relative to one another.

In the Thompson Seedless the Balling-acid ratio of the fruit of the Fresno-to-Davis region was 4.8 per cent at 17° Balling, 4.4 per cent at 18° Balling, and 3.9 per cent at 19° Balling lower than that of the fruit of Kern County. The difference between the Fresno-to-Davis and Coachella and Imperial valleys regions was 14.6 per cent

at 17° Balling, 13.1 per cent at 18° Balling, and 7.7 per cent at 19° Balling.

As in the case of the per cent acidity, there was a relatively small difference in the Balling-acid ratio of the Malaga for the Fresno-to-Davis and the Kern County regions. The difference between the Fresno-to-Davis and the Coachella and Imperial Valleys regions, however, was very marked. At 17° Balling it was 12.0 per cent in favor of the hot desert region. With an increase in Balling the difference became even greater, so that at 18° Balling, it was 18.5 per cent, and at 19° Balling, 22.2 per cent.

The Balling-acid ratio not only further illustrates the influence of regional conditions on the sugar and acid content of the fruit, but it appears to indicate a difference in the effect of the regional conditions at different degrees Balling. At 17° Balling the percentage difference in the Balling-acid ratio between the regions was less than the difference in the per cent acidity, while the reverse is true at 19° Balling. This difference may result from a difference in the conditions prevailing at the time the fruit was 17° Balling and when it reached 19° Balling. Such conditions could hardly account for the difference shown here, however, since all of the samples from a given region were harvested in the course of only a few days. It would seem, therefore, that the difference was owing to the fact that the riper fruit was more susceptible to the influences of climatic conditions. Most growers in the very hot regions believe this to be true.

The Influence of Regional Conditions on Palatability.—The influence of regional conditions on the palatability of grapes can be shown by comparing the scoring of the fruit of the same degree Balling from the three regions. For the Coachella and Imperial valleys region and the Kern County region all of the samples that were analyzed were also scored by tasting. Thus, all of the samples from these regions appear in tables 2 and 3 as well as in tables 4 and 5. In the case of the Fresno-to-Davis region most of the fruit was so acid at 17° Balling as to be unpalatable; hence, to obtain more representative information concerning the per cent acid and the Balling-acid ratio at 17° and 18° not all of the fruit from this region was scored. Enough samples, however, were scored to indicate the relative eating quality at the different degrees Balling. The data on the influence of regional conditions on the palatability of the Thompson Seedless is shown in table 4 and that of the Malaga is shown in table 5.

The figures of table 4 show that 61 per cent of the fruit from the Coachella and Imperial region was considered as mature at 17°

Balling. Of the fruit from the Kern County region 38 per cent was scored as being mature at 17° Balling, and of that from the Fresno-to-Davis region only 8 per cent was considered good to eat at 17° Balling. At 18° Balling there is an increase in the per cent of mature fruit from each region, so that 83 per cent of the Coachella and Imperial fruit, 61 per cent of the Kern County fruit, and 37 per cent of the Fresno-to-Davis fruit was scored as being good to eat. A similar increase was found at 19° Balling. In the Thompson Seedless, therefore, the influence of these regional conditions on palatability has amounted to about 1° Balling. That is, 61 per cent of the fruit of

TABLE 4

The Influence of Regional Conditions on the Palatability of Thompson Seedless Grapes

Region	Number of samples	Degree Balling	Number of samples scoring mature*	Per cent of samples scoring mature*
Coachella and Imperial valleys	41	17	25	61
	46	18	30	83
	54	19	50	92
Kern County	42	17	16	38
	33	18	20	61
	41	19	37	90
Fresno-to-Davis	26	17	2	8
	22	18	8	37
	28	19	20	72

* Mature as used here refers to all of the fruit that was considered good to eat. It embraces the scores: fair, good, very good, and excellent.

the Coachella and Imperial region was good at 17° Balling, 61 per cent of the fruit from Kern County was good at 18° Balling, and 72 per cent of the fruit from Fresno-to-Davis was considered mature at 19° Balling.

As indicated by the figures of table 5, a very high percentage of the Malaga fruit from the Coachella and Imperial valleys above 17° Balling was scored mature. Even at 17° Balling, 78 per cent of the fruit was considered good to eat. For the Kern County region 38 per cent of the samples were considered palatable at 17° Balling, 57 per cent were good at 18° Balling, and 86 per cent were good at 19° Balling. In the region Fresno-to-Davis 10 per cent of the samples were mature at 17° Balling, 40 per cent at 18° Balling, and 57 per cent at 19° Balling. In Kern County and the Fresno-to-Davis regions

the percentage of Malaga samples that were considered mature was almost the same as for the Thompson Seedless.

Ribier was also collected in sufficient quantity from the Kern County and the Fresno-to-Davis regions to further illustrate the influence of regional conditions on palatability. In this variety all of the 44 samples of 17° and 18° Balling collected in the former region were considered mature. Of the 56 samples of 17° and 18° Balling collected in the region Fresno-to-Davis 80 per cent were scored mature.

TABLE 5

THE INFLUENCE OF REGIONAL CONDITIONS ON THE PALATABILITY OF MALAGA GRAPES

Region	Number of samples	Degree Balling	Number of samples scoring mature	Per cent of samples scoring mature
Coachella and Imperial valleys	63	17	49	78
	47	18	40	85
	69	19	65	94
Kern County	8	17	3	38
	7	18	4	57
	14	19	12	86
Fresno-to-Davis	30	17	3	10
	52	18	21	40
	23	19	13	57

THE INFLUENCE OF SEASONAL TEMPERATURES ON THE COMPOSITION AND PALATABILITY OF GRAPES

The dates of ripening and of the development of color vary with the season. The most general and perhaps the principal factor of the cause of this is the mean of the daily maximum air temperature during the development and ripening of the fruit. Fortunately, for the purpose of the investigation, there was an unusually large variation in this factor during the three seasons covered and one of them diverged widely from the mean of the localities considered.

The season of 1931 was peculiar in that for the early sections the mean daily maximum temperature was considerably below normal, while in the later sections the mean daily maximum temperature was well above normal. In the Coachella Valley there was also a sufficient difference in the temperature before and during harvesting between the season of 1929 and that of 1930 to be reflected in the fruit.

The Coachella Valley.—This valley is the earliest commercial grape-growing section in California. Here the fruit develops very rapidly, i.e. the period of time required for the growth and maturing of the fruit is relatively short. In view of the rapid development of the fruit, the temperature records for this section were compiled for a period of thirty days before the date of harvesting. A period of such length was sufficient to cover the ripening period and hence to embrace the chief effects of temperature on the composition and palatability of the fruit at harvesting.

The influence of the seasonal temperatures of the Coachella Valley on the degree Balling of grapes of the same per cent acidity is shown in table 6. The influence of the same conditions on the per cent acidity and the eating quality of the fruit at the same degree Balling is shown in table 7.

TABLE 6

The Influence of Seasonal Temperature on the Degree Balling of Grapes of the Same Acid Content; Coachella Valley

Variety	Year	Mean maximum temperature for 30 days before harvesting, degrees Fahrenheit	Per cent acid						
			0.55 to 0.60	0.60 to 0.65	0.65 to 0.70	0.70 to 0.75	0.75 to 0.80	0.80 to 0.85	0.85 to 0.90
			Degree Balling						
Thompson Seedless	1929	109.2	18.5	18.6	18.7	18.1	18.2	.....	.....
	1930	105.6	19.3	19.4	19.4	19.2	19.0	.....	.....
	1931	97.9	.....	.....	.....	20.3	20.6	20.2	20.1
Malaga	1929	109.2	18.6	17.8	18.3	18.5	18.3	.....	.....
	1930	105.6	18.5	18.7	18.9	18.4	18.9	.....	.....
	1931	97.9	.....	19.9	19.9	19.5	19.2	19.1	18.7

As was indicated in the discussion of the influence of regional conditions in connection with table 2, the figures of table 6 show no significant difference in the degree Balling at the various per cents of acidity over the range of acidity of the samples. There is, however, a definite indication of the influence of seasonal temperatures on the degree Balling of the samples of fruit of the same acidity. In 1929 the average Balling reading of the Thompson Seedless fruit over the entire range of acidity was 0.8° lower than in 1930 and 1.9° lower than in 1931. For the Malaga the Balling reading of the 1929 fruit was 0.4° lower than that of 1930 and 1.2° lower than that of 1931. These differences in degree Balling are directly correlated with the seasonal conditions of temperature. In 1929 the mean maximum

temperature for the thirty-day period before harvesting was 3.6° F higher than in 1930 and 11.3° F higher than in 1931. Similarly, the difference in the degree Balling was less between 1929 and 1930 than between 1930 and 1931.

TABLE 7

THE INFLUENCE OF SEASONAL CONDITIONS ON THE ACIDITY AND THE PALATABILITY OF GRAPES OF THE SAME DEGREE BALLING

Variety	Years	Mean maximum temperature 30 days before harvesting, degrees Fahrenheit	Degree Balling of expressed juice			Scoring of samples of 17° to 19° Balling	
			17.0 to 17.9	18.0 to 18.9	19.0 to 19.9	Per cent scored mature*	Per cent scored poor
			Per cent acid				
Thompson Seedless	1929	109.2	0.69	0.66	0.66	85	15
	1930	105.6	0.79	0.77	0.76	45	55
	1931	97.9	1.02	1.04	1.04	11	89
Malaga	1929	109.2	0.66	0.62	0.56	78	22
	1930	105.6	0.71	0.67	0.62	65	35
	1931	97.9	0.86	0.77	0.74	28	72

* Mature as used here refers to all of the samples scoring fair or better.

The figures of table 7 show that with a drop from 109.2° to 105.6° F in the mean daily temperature for thirty days before harvesting, there was a marked increase in the acidity. In the Thompson Seedless this increase was 14.5 per cent at 17° Balling, 16 per cent at 18° Balling, and 15.2 per cent at 19° Balling in 1930 as compared to that of 1929. With a further reduction in the mean temperature during the thirty-day period before harvesting from 105.6° F in 1930 to 97.9° F in 1931 there was an increase in the acidity of 29 per cent at 17° Balling, 35 per cent at 18° Balling, and 35 per cent at 19° Balling. The increases in the acidity of the Malaga at the same degree Balling with the drops in the mean maximum temperatures as indicated above were proportional to those of Thompson Seedless but of only about one-half the magnitude.

The influence of the seasonal conditions in the Coachella Valley on palatability is shown in the two columns at the right of table 7. For the Thompson Seedless samples 17°, 18°, and 19° Balling 85 per cent were considered good to eat in 1929, 45 per cent in 1930, and 11 per cent in 1931. For the Malaga samples of these same degrees Balling 78 per cent were scored as mature in 1929, 65 per cent in 1930, and 28 per cent in 1931. The palatability of the samples reflects the relative influence of the seasonal conditions on the relation of the degree Balling to the per cent acidity. This relation was influenced

more by the seasonal conditions in the Thompson Seedless than in the Malaga. Likewise the Thompson Seedless samples show a greater spread in palatability for the three years than those of the Malaga.

Kern County and Fresno County.—The influence of the temperature conditions of those two regions will be presented together. Here the period required for the maturing of the fruit is longer than in the Coachella Valley. It is also somewhat longer in Fresno than in Kern County. With the lengthening of the season required for the development of the fruit the period of time before harvesting for which the temperature records were compiled was increased to 40 days.

The influence of the seasonal temperatures of these sections on the degree Balling of grapes of the same per cent acidity is shown in table 8 and the influence on the per cent acidity and palatability is shown in table 9.

TABLE 8

The Influence of Seasonal Temperature on the Degree Balling of Grapes of the Same Acid Content

Variety	Year	Mean maximum temperature for 40 days before harvesting, degrees Fahrenheit	Per cent acid					
			0.60 to 0.65	0.65 to 0.70	0.70 to 0.75	0.75 to 0.80	0.80 to 0.85	0.85 to 0.90
			Degree Balling					
Thompson Seedless (Kern County)	1929	101.6	20.1	20.2	19.6	19.4	19.2	.....
	1930	101.8	19.2	19.4	19.2	19.0	19.5	.....
	1931	96.3	.....	.....	21.0	21.9	21.8	21.1
Malaga (Fresno County)	1929	93.5	.....	21.6	21.3	21.4	20.7	20.4
	1930*	92.5						
	1931	103.2	19.1	18.5	18.5	18.7	18.1	.....

* Only 24 samples of Malaga were collected in Fresno County in 1930. Owing to the similarity in the temperature of this season with that of 1929, as indicated in table 8, these samples are combined with those of 1929.

In these regions the mean maximum temperature for the forty-day period before harvesting in 1929 and 1930 was almost the same. The degree Balling of the fruit for these seasons at the same per cent acidity also was almost the same. For Kern County in 1931 when the mean maximum temperature for the period before harvesting was 5.5° F lower than in 1929 and 1930, the Balling for the fruit of the same per cent acidity was 1.9° Balling higher.

The data of table 8 show a reversal of temperature conditions in Fresno County as compared to Kern County and the Coachella Valley sections. Here the mean maximum temperature for the forty-day period before harvesting was higher in 1931 than in 1929 and 1930.

The increase of 10.2° F in the temperature of 1931 over the average for the same period of time in 1929 and 1930 was accompanied by a reduction of 2.5° Balling of the fruit of the same per cent acidity in this season.

TABLE 9

THE INFLUENCE OF SEASONAL CONDITIONS ON THE ACIDITY AND THE PALATABILITY OF GRAPES OF THE SAME DEGREE BALLING

Variety	Year	Mean maximum temperature for 40 days before harvesting, degrees Fahrenheit	Degree Balling of expressed juice			Scoring of samples 17° to 19° Balling	
			17.0 to 17.9	18.0 to 18.9	19.0 to 19.9	Per cent scored mature	Per cent scored poor
			Per cent acid				
Thompson Seedless (Kern Co.)	1929	101.6	0.78	0.76	0.69	46	54
	1930	101.8	0.80	0.77	0.70	42	58
	1931	96.3	1.08	1.09	1.05	14	86
Malaga (Fresno County)	1929	93.5	0.78	0.75	0.70	38	62
	1930	92.5					
	1931	103.2	0.68	0.64	0.59	71	29

The figures of table 9 indicate that under conditions of about the same temperature the acidity of the grapes of the same degree Balling was about the same. There was no significant difference in the acidity of the Thompson Seedless in Kern County in 1929 and 1930. The same was true for the Malaga in Fresno in these seasons. With a drop in 1931 of 5.5° F in Kern County in the mean maximum temperature for the period before harvesting the acidity of Thompson Seedless was 35 per cent higher at 17° Balling, 41 per cent higher at 18° Balling, and 50 per cent higher at 19° Balling than in 1929 and 1930. In the Fresno section, on the contrary, where the temperature for 1931 was 10.2° F higher than in 1929 and 1930 there was a reduction of the acidity in this season of 13 per cent at 17° Balling, 15 per cent at 18° Balling, and 16 per cent at 19° Balling.

During 1929 and 1930, when the seasonal influences on the fruit of the Kern section were about the same, approximately the same amount of fruit at 17°, 18°, and 19° Balling was considered mature by the scorers. The great increase in the acidity of the fruit of these degrees Balling in this section in 1931 caused the scorers to mark only 14 per cent of it mature.

Of the fruit of 17°, 18°, and 19° Balling collected in the Fresno section in 1929 and 1930 the scorers marked 38 per cent mature. The considerable reduction in the acidity of the fruit in 1931 resulted in the scoring of 71 per cent of the fruit of this season as mature.

THE RELATION OF ACIDITY AND DEGREE BALLING TO PALATABILITY

In the preceding parts of this paper the influence of regional and seasonal conditions on the acidity and the sugar content of the expressed juice of grapes was discussed. The relation of these substances to the eating quality of the grape will now be considered. For this purpose three varieties will be selected: one to represent the

TABLE 10

The Relation of Per Cent Acid and Degree Balling to the Palatability of Grapes

Degree Balling	Per cent acid										
	0.35 to 0.40	0.40 to 0.45	0.45 to 0.50	0.50 to 0.55	0.55 to 0.60	0.60 to 0.65	0.65 to 0.70	0.70 to 0.75	0.75 to 0.80	0.80 to 0.85	0.85 to 0.90
	Palatability scores*										
Molinera (Red Malaga)											
16.0 to 16.9	22.5	22.5	20.0	15 0	17.5	15.0	7.5				
17.0 to 17.9	27.5	25.0	22.5	22.5	20.0	17.5	12.5				
18.0 to 18.9	22.5	25.0	32.5	25.0	22.5	22.5	20.0				
19.0 to 19.9	40.0	40.0	40.0	42.5	35.0	37.5	35.0				
20.0 to 20.9	42.5	47.5	45.0	40.0	47.5	40.0	40.0				
21.0 to 21.9	.....	57.5	62.5	62.5	52.5	52.5	60.0				
Emperor											
17.0 to 17.9			20.0	25.0	22.5	20.0	17.5	22.5	15.0		
18.0 to 18.9			25.0	22.5	22.5	30.0	30.0	25.0	20.0		
19.0 to 19.9			27.5	30.0	35.0	32.5	32.5	30.0	22.5		
20.0 to 20.9			37.5	37.5	35.0	37.5	35.0	35.0	25.0		
21.0 to 22.9			45.0	42.5	37.5	45.0	45.0	42.5	37.5		
23			52.5	45.0	50.0	47.5	55.0	42.5	37.5		
Thompson Seedless											
17.0 to 17.9					25.0	30.0	32.5	25.0	25.0	20.0	15.0
18.0 to 18.9					30.0	32.5	32.5	35.0	27.5	25.0	17.5
19.0 to 19.9					32.5	37.5	37.5	32.5	30.0	27.5	17.5
20.0 to 21.9					42.5	42.5	42.5	45.0	37.5	37.5	30.0
22.0 to 23.9					50.0	50.0	50.0	52.5	50.0	42 5	37.5
24 or more					62.5	62.5	62.5	67.5	65.0	52.5	47.5

* A palatability score of 25 or more indicates that the fruit was fair or better in eating quality.

group of varieties of low acidity, another to represent those of medium acidity, and a third to represent those of high acidity. To show the relation of each of these substances to palatability, the average scores of the tasters for the samples at each degree Balling, and at the various per cents of acid over the entire range of acidity for the varieties, are included in table 10. The scores at each degree Balling,

i.e. the figures across the table, show the influence of acidity on eating quality. The figures at a given per cent of acidity, i.e., the scores shown in the various columns of the table, indicate the relation of degree Balling to palatability.

The figures of table 10 indicate a relation between acidity and palatability. In each variety the palatability scores are reduced as the acidity becomes somewhat high. This reduction was most pronounced in the samples of low Balling. Yet with the highest degree Balling shown there was a slight reduction in the palatability score of the samples of each variety, except those of Molinera, at the higher acidities. This relation of acidity to eating quality for the three varieties is possibly more clearly illustrated by the graphs of figure 2. The significance of the relation of acidity to eating quality is shown by the correlation computation of table 11.

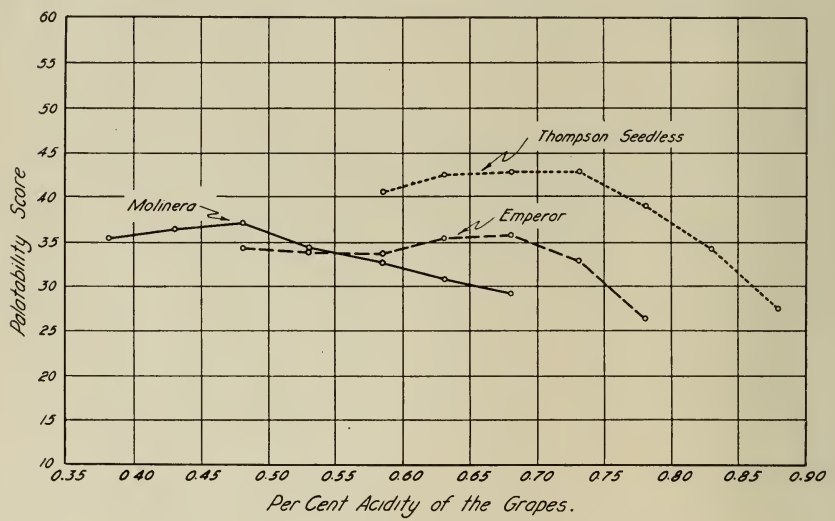

Fig. 2.—The relation of acidity to eating quality.

The relation of degree Balling to palatability, as shown by the figures of table 10, is much more definite than that shown for the acidity. An increase in the degree Balling was accompanied by a decided increase in palatability at each of the different per cents of acidity. The increase in score between the lowest and the highest degree Balling for each of the varieties at a given acidity was 100 per cent or more. This relation of degree Balling to eating quality is more clearly indicated by the graphs of figure 3. Its significance is further confirmed by the data of table 11.

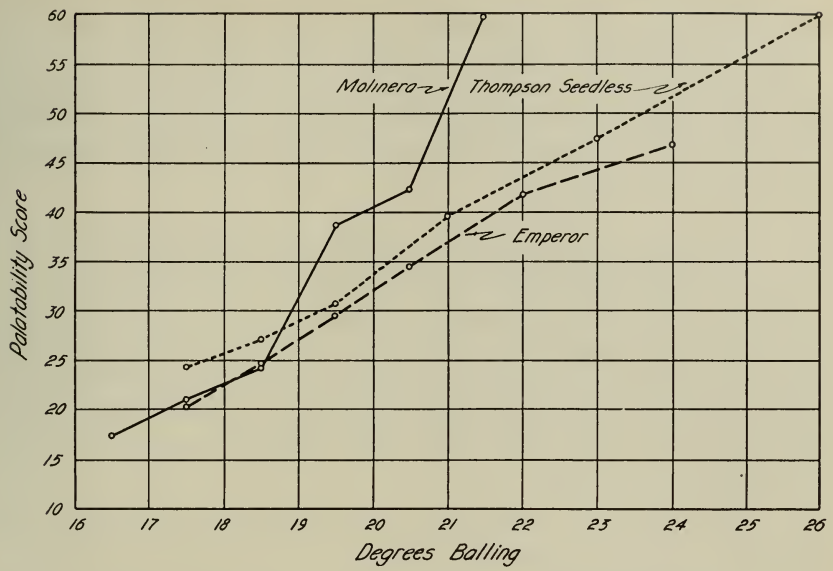

Fig. 3.—The relation of degree Balling to eating quality.

TABLE 11

The Correlation of Acidity and Degree Balling with Palatability

Variety	Years included	Correlations	
		Balling with palatability	Acidity with palatability
Thompson Seedless	1927–1930	+0.735±0.014	−0.523±0.019
Malaga	1927–1930	+0.649±0.017	−0.640±0.018
Tokay	1927–1930	+0.635±0.020	−0.368±0.030
Emperor	1927–1930	+0.681±0.018	−0.144±0.034
Ribier	1927–1930	+0.656±0.021	−0.420±0.031
Muscat	1927–1930	+0.546±0.035	−0.367±0.044
Molinera (Red Malaga)	1927–1930	+0.815±0.014	+0.009±0.041
Ohanez	1929	+0.715±0.049	−0.480±0.057

The figures of table 11 indicate that the correlation of acidity and palatability is of questionable significance when applied to all of the varieties. In the Thompson Seedless and Malaga the average correlation for the four seasons is sufficiently high to be decidedly significant. In single seasons and for given localities, however, the correlations for these varieties dropped in some instances as low as -0.30 ± 0.12 and -0.35 ± 0.10, respectively. These correlations are of doubtful significance. In the Tokay, Ribier, Muscat, and Ohanez the correlation figures are near the lower limits of being con-

sidered significant. The figures for the Emperor and Molinera fail to show any significant correlation of acidity with eating quality.

The correlations of degree Balling and palatability are all very high. The influence of seasonal and regional conditions upon these correlations have not been as clearly indicated as for the correlations of acidity and palatability.

ACIDITY AS A MEANS OF MEASURING MATURITY

Many of the poor table grapes that get on the markets are poor because they are green, i.e., not ripe enough for dessert purposes. This fruit is immature because its acidity is too high in relation to its sugar content. To overcome this condition it has frequently been suggested that acidity rather than degree Balling be used as a basis for measuring maturity.

That the acidity of the grape is not a suitable constituent for the purposes of standardization is shown in tables 10 and 11 and figure 2. It bears a certain relation to palatability but its influence *per se* on palatability is not sufficiently marked. For the three varieties used the difference in the palatability score was only 17 per cent in the acidity range 0.38 to 0.63 per cent, for Molinera; 7 per cent in the acidity range 0.48 to 0.73 per cent, for Emperor; and 9 per cent in the acidity range 0.58 to 0.78 per cent, for Thompson Seedless. When it is considered that these ranges in acidity include the majority of the grapes of these varieties that appear on the markets, it is obvious that the difference in eating quality at the different percentages of acid is not sufficient to make it possible to separate the good from the poor grapes on the basis of acidity. The slopes of the graphs in figure 2 also show this indefiniteness of the relation of acidity and palatability. Except for the point of highest acidity in the Emperor and the two points of highest acidity in the Thompson Seedless, the graphs are relatively straight.

Further evidence against the use of acidity as a basis of measuring maturity is offered by the correlation calculations shown in table 11. Here the correlation of acidity with palatability is shown to range from -0.640 ± 0.018 in the Malaga down to -0.144 ± 0.034 in the Emperor and on down to $+0.009 \pm 0.041$ in the Molinera. In other words, there is no consistently significant correlation between acidity and eating quality when all of the varieties are considered. Even the relatively high average correlations shown for the Malaga and Thompson Seedless, lose their apparent importance when the correlations

for these varieties in the various localities in which they are grown are considered individually. To be of value as a measure of maturity the relation of acidity to palatability would of necessity have to be fairly constant for all of the varieties and especially so for the individual varieties.

DEGREE BALLING AS A MEANS OF MEASURING MATURITY

The degree Balling of the expressed juice of grapes has been used for many years in California as a means of measuring maturity. Its use in this connection was given legal recognition in the Standardization law of 1915. Although no single composition test has been found sufficiently accurate as a measure of the maturity of grapes in this investigation, degree Balling has a higher degree of correlation with eating quality than any other. This high degree of correlation is indicated by the figures of tables 10 and 11.

Despite its long use as a means of determining maturity and the above data which appear to indicate that degree Balling should serve well for this purpose, its use in the standardization of table grapes has not been entirely satisfactory. In some seasons it has worked well, while in others a relatively large quantity of fruit that met the Balling requirement, but which was nevertheless poor in eating quality, was placed on the markets. The nature of the limitations of degree Balling can be shown by indicating how it has functioned as a means of separating the good and poor samples of fruit used in these tests. First, figures will be presented to show the actual results obtained with the degree Balling requirement as set forth in the Standardization law of 1931. After this, the possibility of improving the functioning of this means of determining palatability by raising the degree Balling requirement will be indicated.

The 1931 Standardization Law.—The degree of satisfaction with which the present Balling requirement is functioning may be indicated by showing the percentage of poor fruit that it permits to reach the markets. To do this, the samples of fruit used in this investigation that were of a Balling reading equal to or above the present legal requirement were divided into two groups. One group was made up of the samples that were considered poor in eating quality by the scorers, and the other was made up of all the samples that were considered fair or better in eating quality. The results of this grouping of the samples on the basis of palatability is shown in table 12. The good fruit excluded by this requirement is also shown.

These figures indicate that of the fruit meeting the 1931 standardization requirements as regards degree Balling 10 to 26 per cent was considered to be poor in eating quality. On this basis an average of 20.0 per cent of the fruit of the eleven varieties that met this requirement was scored as not being good to eat. This is indeed a very high percentage. If the samples of fruit were representative of the fruit that moved to market, and there is every reason to believe that they were, the 1931 degree Balling requirement is not sufficiently effective as a means of keeping the poor grapes off our markets.

TABLE 12

THE PRESENT DEGREE BALLING REQUIREMENT AS A MEANS OF MEASURING MATURITY IN RELATION TO PALATABILITY

Variety	The 1931 standardization requirement*	Number of samples equal to or above the 1931 degree Balling requirement	Fruit scoring fair or better	Fruit scoring poor	Fruit scoring fair or better excluded by the 1931 degree Balling requirement
	degrees Balling		*per cent*	*per cent*	*per cent*
Thompson Seedless	17	709	74	26	0 0
Malaga	17	648	83	17	0.8
Tokay	17	469	78	22	0.8
Ohanez	17	104	81	19	0.0
Cornichon	17	59	84	14	0.4
Muscat	18	200	90	10	1.5
Emperor	16	438	76	24	0.0
Ribier	16	242	85	15	3.6
Molinera (Red Malaga)	16	226	84	16	0.4
Rish Baba	16	65	88	12	0.0
Olivette Blanche	16	45	80	20	0.0

* The California Fruit, Nut, and Vegetable Standardization Act of 1931.

Higher Degree Balling Requirements.—A raise in the degree Balling requirement has been advocated by many individuals as a solution to the limitations of the present and past Balling requirements. The probable success of such a revision is indicated by the figures of tables 13 and 14. The figures of these tables are similar to those of table 12 except that in table 13 the minimum is one degree Balling and in table 14 two degrees Balling above the 1931 requirement. The percentage of good fruit eliminated by these increases in degree Balling is shown in the column at the right of the tables.

The figures of table 13 show that an increase of 1° Balling in the minimum requirement has excluded 30 per cent of the poor fruit that was equal to or above the 1931 Balling requirement. The increase of 1° Balling has also excluded an average of 4.8 per cent of the fruit that scored fair or better.

TABLE 13

A Degree Balling Requirement of 1° Higher Than That of 1931 as a Means of Measuring Maturity in Relation to Palatability

Variety	Degrees Balling	Fruit scoring fair or better	Fruit scoring poor	Fruit scoring fair or better excluded by the increase of 1° Balling
		per cent	*per cent*	*per cent*
Thompson Seedless	18	90	10	6
Malaga	18	92	8	9
Tokay	18	84	16	1
Ohanez	18	88	12	0
Cornichon	18	88	12	34
Muscat	19	92	8	3
Emperor	17	79	21	0
Ribier	17	95	5	13
Molinera (Red Malaga)	17	92	8	1
Rish Baba	17	100	0	5
Olivette Blanche	17	85	36	0

TABLE 14

A Degree Balling Requirement of 2° Higher Than That of 1931 as a Means of Measuring Maturity in Relation to Palatability

Variety	Degrees Balling	Fruit scoring fair or better	Fruit scoring poor	Fruit scoring fair or better excluded by the increase of 2° Balling
		per cent	*per cent*	*per cent*
Thompson Seedless	19	95	5	15
Malaga	19	97	3	21
Tokay	19	91	9	4
Ohanez	19	92	8	8
Cornichon	19	100	0	64
Muscat	20	100	0	6
Emperor	18	85	15	2
Ribier	18	99	1	26
Molinera (Red Malaga)	18	99	1	8
Rish Baba	18	100	0	16
Olivette Blanche	18	93	7	7

By raising the minimum 2° Balling above the 1931 requirement, as shown in table 14, 75 per cent of poor fruit was excluded. This increase of 2° Balling, although quite effective in reducing the percentage of poor fruit that was admitted by the 1931 requirement, increased the amount of good fruit that was excluded to 12 per cent.

These figures clearly illustrate the insufficiency of degree Balling as a means of measuring maturity. It is true that a sufficiently high degree Balling will exclude practically all of the poor fruit. To

increase the requirement to that extent, however, is too costly in delaying the harvesting of the considerable quantity of fruit that is good to eat before it reaches this higher standard. In the warmer regions such a delay in harvesting, especially in the hotter seasons, would result in the loss of much of the fruit that becomes good to eat at 17° and 18° Balling.

The Defects of Degree Balling as a Means of Measuring Maturity.—In view of the very high degree of correlation between degree Balling and palatability shown in tables 10 and 11 and figure 3, and the insufficiency of degree Balling as a means of measuring palatability as shown in tables 12, 13, and 14, it would appear that something has been missed in the endeavor to find the actual relation of degree Balling to palatability. The factor which would most likely clear up this apparent discrepancy is the influence of regional and seasonal conditions on the correlation of degree Balling and palatability.

In collecting the samples of fruit for this investigation they were all tasted so as to have them fall within a given range of palatability. This procedure tended to mask the effects of regional and seasonal conditions by bringing about a shift in the degree Balling of the fruit collected in different regions and seasons. When the conditions were such that the fruit became palatable at a low degree Balling, more fruit toward the lower end of the Balling range was collected. On the contrary, when the conditions were such that the fruit of the lower degrees Balling was unpalatable, the majority of the samples were collected in the middle or at the higher part of the degree Balling range. Since all of the fruit was within the same relatively narrow range of palatability it is not surprising that the correlation between its degree Balling and palatability is about the same in the different regions and seasons.

Although the data collected do not clearly show the influence of seasonal and regional conditions on the correlation of degree Balling and palatability when the entire Balling range over which fruit was collected is used, the importance of the influence of these conditions can be indicated by using only the fruit of 17°, 18°, and 19° Balling. The influence of regional conditions on palatability at these degrees Balling as indicated by the scores of the tasters is shown in table 15. The influence of seasonal conditions on the palatability score of fruit of the same degrees Balling is indicated in table 16.

The figures of table 15 indicate that the palatability score of the Thompson Seedless fruit of the Coachella and Imperial valleys was 17

per cent higher at 17° Balling, 40 per cent higher at 18° Balling, and 36 per cent higher at 19° Balling than that of Kern County. The score of the fruit of this variety was 47 per cent at 17° Balling, 53 per cent at 18° Balling, and 44 per cent at 19° Balling higher in Coachella and Imperial valleys than in the region Fresno-to-Davis. Differences of about the same magnitude are shown by the scores for the Malaga fruit of these regions.

TABLE 15

The Influence of Regional Condition on the Palatability Score of Grapes of 17° to 19° Balling, for 1929

Variety	Region	Palatability scores		
		At 17.0° to 17.9° Balling	At 18.0° to 18.9° Balling	At 19.0° to 19.9° Balling
Thompson Seedless	Coachella and Imperial valleys	30	45	48
	Kern County	25	27	31
	Fresno-to-Davis	16	21	27
Malaga	Coachella and Imperial valleys	34	37	39
	Kern County	24	31	29
	Fresno-to-Davis	12	15	22

TABLE 16

The Influence of Seasonal Conditions on the Palatability Score of Grapes of 17° to 19° Balling

Variety	Region	Year	Mean maximum temperature before harvesting,* degrees Fahrenheit	Palatability scores		
				At 17.0° to 17.9° Balling	At 18.0° to 18.9° Balling	At 19.0° to 19.9° Balling
Thompson Seedless	Coachella Valley	1929	109.2	31	44	46
		1930	105.6	20	26	37
		1931	97.9	12	13	19
	Kern County	1929	101.6	26	27	30
		1930	101.8	27	26	31
		1931	96.3	17	21	25
Malaga	Coachella Valley	1929	109.2	33	38	39
		1930	105.6	22	26	31
		1931	97.9	19	24	26
	Fresno County	1929	93.5	12	15	22
		1930	92.5			
		1931	103.2	26	30	33

* For a 30-day period in Coachella Valley and a 40-day period in Kern and Fresno counties.

The figures of table 16 show that the drop in temperature from 109.2° F in 1929 to 105.6° F in 1930 was accompanied by a reduction in the palatability score of Thompson Seedless in the Coachella Valley of 35 per cent at 17° Balling, 41 per cent at 18° Balling, and 24 per cent at 19° Balling. The further reduction in the mean maximum temperature for the thirty-day period before harvesting to 97.9° F in 1931 reduced the score 61 per cent at 17° Balling, 71 per cent at 18° Balling, and 37 per cent at 19° Balling below the score of 1929. The influence of the seasonal conditions of the Coachella Valley on the palatability scores of the Malaga at 17°, 18°, and 19° Balling was similar to that of the Thompson Seedless.

In Kern County the mean maximum temperature for the forty days before harvesting was almost the same during 1929 and 1930. In these seasons the palatability scores at the degrees Balling indicated also were almost the same. In 1931, however, when the mean maximum temperature was only 96.3° F there was a reduction in the palatability score of 33 per cent at 17° Balling, 21 per cent at 18° Balling, and 18 per cent at 19° Balling.

For Fresno County where the temperature for the period before harvesting was higher in 1931 than in 1929 and 1930 the palatability score also was higher. This increase accompanying the 10.2° F increase in the mean maximum temperature was 110 per cent at 17° Balling, 100 per cent at 18° Balling, and 50 per cent at 19° Balling.

The figures of tables 17 and 18 indicate the extent to which the palatability score of grapes of the same degree Balling was influenced by regional and seasonal conditions. They clearly show that so long as grapes are grown in regions which differ climatically, and so long as seasons vary, degree Balling alone cannot be expected to serve perfectly as a means of measuring palatability.

In the past the state was divided into two regions for the purpose of increasing the efficiency of degree Balling as a means of measuring maturity. Such a division might improve the accuracy of this means as a measure of eating quality to some extent, provided that sufficient differences are made in the degree Balling requirement for the different regions. It would, however, never achieve entirely satisfactory results since it removes only the influence of regional conditions. The influence of seasonal conditions would continue to move the palatability score which indicates the lower limit of good eating quality through the ripening range of 16° to 20° Balling, thus nullifying our best efforts to make degree Balling a workable means of measuring maturity.

THE BALLLING-ACID RATIO AS A MEANS OF MEASURING MATURITY

The conditions which have been largely responsible for the failure of either per cent acid or degree Balling used alone as a means of measuring maturity in the sense of eating quality indicate that these means might give promise if used in combination. In combination these composition factors embrace the very high correlation of degree Balling and palatability as well as the condition of fluctuating acidity which has been principally responsible for the partial failure of the degree Balling standard. The Balling-acid ratio of the expressed juice of the grapes is obtained by dividing the degree Balling (per cent total solids) by the per cent acidity. The relation of these two factors to one another has long been known to influence greatly the palatability of grapes. In the past, however, sufficient data to indicate the utility of this relation or ratio as a means of measuring maturity have been lacking.

The efficiency of the Balling-acid ratio as a means of measuring maturity can be indicated by applying it to the samples of fruit that have been used in this investigation. For this purpose the samples are divided on the basis of the Balling-acid ratio indicated for each variety in table 17. All fruit meeting this ratio was admitted irrespective of its palatability score. Some of this fruit may have had a score of less than 25 (fair); if so, it was listed with the samples of poor fruit admitted by this test. Fruit having a palatability score of 37 or more was admitted even though its Balling-acid ratio was not equal to or above that indicated for the variety. If its Balling-acid ratio was below that indicated, such fruit was listed among the samples of good fruit excluded by this test. Fruit having a palatability score between 25 and 37 was admitted when its Balling-acid ratio was equal to or above that indicated and excluded when the ratio was below that indicated for the variety in table 17. This latter fruit is marginal. Its inclusion or elimination was immaterial so far as the Balling-acid ratio test is concerned. It may be considered as good to eat by those who like their fruit tart. It would be considered poor by those who like their grapes sweet. The results obtained on this basis with the Balling-acid ratio as a means of measuring maturity in relation to eating quality are shown in table 17.

The figures of table 17 show the very high degree of efficiency with which the poor fruit was excluded by the Balling-acid ratio test. In the case of Ohanez and Cornichon 7.5 and 7.0 per cent, respectively, of

poor fruit was admitted. From these figures the amount of poor fruit admitted in the other varieties varied downward to 1.0 per cent in Muscat. The average amount of poor fruit admitted by this test for all the varieties was 2.5 per cent.

This exclusion of poor fruit was affected without the loss of an appreciable amount of good fruit. In Emperor 1.1 per cent of good fruit was excluded. In no other variety did the elimination of good fruit amount to as much as 1 per cent. For the eleven varieties the loss of good fruit by this test amounted to 0.4 per cent.

TABLE 17

THE BALLING-ACID RATIO AS A MEANS OF MEASURING MATURITY IN RELATION TO PALATABILITY

Variety	Number of samples collected	Balling-acid ratio	Fruit scoring poor admitted	Fruit scoring fair or better excluded
			per cent	*per cent*
Thompson Seedless	875	25:1	2.0	0.0
Malaga	760	25:1	2.5	0.7
Ribier	325	25:1	1.5	0.0
Emperor	460	30:1	3.7	1.1
Ohanez	120	30:1	7.5	0.0
Muscat	200	30:1	1.0	0.5
Cornichon	72	30:1	7.0	0.0
Tokay	492	35:1	1.4	0.8
Molinera (Red Malaga)	260	35:1	3.5	0.0
Olivette Blanche	48	35:1	2.0	0.0
Rish Baba	68	40:1	3.0	0.0

The figures of table 17 do not fully show the effectiveness with which the Balling-acid ratio indicated serves as a means of excluding sour grapes. The majority of the samples of poor fruit admitted by this test were poor because they were flat or insipid and not because they were green or high in acid. Of the poor fruit admitted 85 per cent was of this character. Therefore, this test admitted only 0.38 per cent of sour or immature fruit.

None of the tests have excluded the flat or insipid fruit. The samples included in this investigation were collected with the view of making the range of sampling more complete. Fortunately, in actual harvesting and packing operations this fruit would usually be eliminated because of its soft texture and its dull lifeless appearance.

The superiority of the Balling-acid ratio to degree Balling alone as a means of measuring maturity is indicated by the figures of table 17 as compared to the figures of tables 12, 13, and 14. The present degree Balling requirement admitted an average of 20.0 per cent of

poor fruit for the eleven varieties. It excluded 0.7 per cent of good fruit. The Balling-acid ratio admitted only an average of 2.5 per cent of poor fruit and excluded only 0.4 per cent of the good fruit. To raise the degree Balling requirement 2° reduced the amount of poor fruit admitted to an average of 5.8 per cent for the eleven varieties; however, it excluded 12 per cent of the good fruit.

Accompanying its superiority over degree Balling as a means of separating the good grapes from those that are sour the Balling-acid ratio is not affected by climatic (regional and seasonal) conditions. In very hot regions where the acidity is low and where grapes become palatable at a relatively low sugar content the low acidity enables the grapes to meet the Balling-acid ratio requirement at a relatively low degree Balling. In the cooler regions, on the contrary, where the acidity is higher, and where higher quality is possible owing to the higher acid content, the grapes must be left on the vines until they have attained a higher degree Balling in order to meet the Balling-acid ratio requirement. In a similar manner the Balling-acid ratio requirement will take care of the fluctuation in acidity which is brought about by hot and cool seasons.

A SUGGESTED MEANS FOR DETERMINING THE MATURITY OF TABLE GRAPES

Of the considerable number of samples used in this investigation practically no grapes scoring fair or better in eating quality were excluded by the minimum degree Balling requirement indicated in table 18. Thus, a degree Balling requirement which is equivalent to the lower limit of the ripening range of the varieties used can be employed to obviate the need of making an acidity determination on fruit of this degree Balling or less. Within the ripening range—from the degree Balling indicated in table 18 up to 20° Balling—the degree Balling and the per cent acid should both be determined, so that the Balling-acid ratio may be used to interpret the maturity of the fruit in relation to its palatability. Above 20° Balling, again, the degree Balling test alone is sufficient. Only a very limited amount of fruit of 20° and higher Balling was found to be poor in eating quality in these tests. It is negligible. Also above 20° Balling the Balling-acid ratios which have been found to apply in the ripening range do not always fit. This is owing to masking of the acid taste by the relatively high percentage of sugar.

The requirements of this method of measuring maturity are shown in table 18.

The different Balling-acid ratio requirements shown for the four groups of varieties are necessary owing to the varietal differences in the relation of degree Balling to acidity. The difference is largely in the per cent acidity of the varieties. This does not seriously complicate the utilization of this means of determining maturity since the ratio for the individual varieties will be the same for the entire state.

TABLE 18

A SUGGESTED STANDARD OF MATURITY FOR TABLE GRAPES

Variety	Minimum degree Balling requirement	Balling-acid ratios for fruit up to 20° Balling
Thompson Seedless	17	25:1
Malaga	17	25:1
Ribier	16	25:1
Ohanez	17	30:1
Cornichon	17	30:1
Muscat	17	30:1
Emperor	17	30:1
Tokay	17	35:1
Olivette Blanche	17	35:1
Molinera (Red Malaga)	16	35:1
Rish Baba	16	40:1

SUMMARY

During the seasons of 1929, 1930, and 1931 more than 3,000 samples of the leading table grape varieties in the ripening range, i.e., from poor to good in eating quality, were collected from all of the principal districts of the state in which they are grown. Each sample was scored for eating quality by at least six individuals. The samples were then pressed and the degree Balling and per cent acidity of the juice obtained.

The influence of regional conditions on the composition and palatability of grapes was indicated by a comparison of the samples collected in the three regions, Coachella and Imperial valleys, Kern County, and Fresno-to-Davis. The fruit of the same degree Balling was considerably higher in acidity in the region Fresno-to-Davis than in the Coachella and Imperial valleys. The fruit of Kern County was intermediate in acidity. Owing to this difference in acidity it was found that the sugar content of fruit of Kern County had to be about 1° Balling higher and the fruit of the region Fresno-to-Davis

about 2.5° Balling higher than that of the Coachella and Imperial valleys if the fruit of all three regions was to be of the same relative eating quality.

The influence of differences in the seasonal temperatures on composition and palatability was very similar to that of the different regional conditions. In cool seasons the acidity was relatively high in relation to degree Balling and in hot seasons it was relatively low. Thus, in hot seasons the fruit became palatable at a lower degree Balling than in cool seasons.

The acidity of the expressed juice of grapes is correlated with their eating quality. This correlation with eating quality, however, is not sufficiently marked to serve as a means of measuring maturity.

The Balling reading of the expressed juice of grapes has a very high degree of correlation with eating quality. If regional and seasonal conditions were constant, the degree Balling of the expressed juice would serve well as a measure of maturity. Owing, however, to the variations in regional and seasonal conditions which very materially influence the relation of acidity to sugar content the Balling reading alone is not a reliable measure of maturity in relation to eating quality.

To raise the present degree Balling requirement would exclude more of the poor fruit, but such a revision would prove very costly in forcing the delay of harvesting of much palatable fruit, especially in hot seasons.

By combining degree Balling and per cent acidity of the expressed juice in the form of a Balling-acid ratio an index of maturity was obtained which embraces the very high correlation of degree Balling and eating quality as well as the condition of fluctuating acidity. The Balling-acid ratio has shown promise as a means of excluding poor fruit without also forcing the delay of harvesting of certain good fruit.

A means for determining the maturity of table grapes by using the degree Balling and the Balling-acid ratio of the expressed juice is suggested.

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